Observations on the flyswatter antenna

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Introduction

Much of the success amateurs have achieved on 10GHz has been due to their being prepared to transport themselves and their equipment to either the tops of hills and mountains to work over long line-of-sight paths, or to the coast to take advantage of super-refraction via humidity ducts formed over the sea. The next advance may well come from using the various modes of anomalous propagation which are known to exist over land paths but which will probably require amateurs to operate from their homes because of the relative unpredictability of these modes.

Operating 10GHz equipment from domestic locations immediately raises problems in mounting the antenna accurately, in weatherproofing it and in feeding signals to it. New waveguide at about £1/ft is quite expensive, and even good quality coaxial cable has a loss typically of 0·5–1dB/ft and therefore cannot be used in long lengths. When this topic was discussed at a recent microwave round table, the most popular solution suggested was to avoid feeder problems altogether simply by mounting *all* the 10GHz equipment up the mast and feeding the dc, af and i.f. supplies instead. This approach still presents problems, of course. If the equipment is to be mounted semi-permanently, then weatherproofing will need careful attention. On the other hand, if it is fitted to the mast only when it is to be used, then some ingenious engineering will be required to ensure that this can be done speedily and reliably as a matter of routine.

An alternative approach is the flyswatter or periscope antenna shown schematically in Fig 1. Although this form of antenna is widely used professionally, it seems to have received little attention from amateurs other than G3JVL. In this system, the feed is usually a parabolic dish (although not necessarily so), and this directs signals upwards at a reflector mounted so as to reflect them horizontally. The area of the reflector illuminated normally is an ellipse which will have the ratio of major to minor dimension equal to 1·41 if the reflector is set at 45°. An elliptical reflector obviously could be used, but a rectangular one is usually preferred for ease of handling, and this actually produces extra gain. The reflector may be planar or curved parabolically, and the purpose of this article is to give an indication of the performance of both types in an amateur context. Although interest in this antenna originated from operating at 10GHz, its potential at other frequencies will be briefly considered.

Design data

The generalized data from which the effective gain of various configurations can be worked out are given in Fig 2 for plane reflectors and in Fig 3 for curved reflectors. The overall gain is a complicated interaction between some factors over which one has a wide choice, such as the size of the feed and reflector, other factors such as the feed/reflector spacing over which one has a restricted choice, and fixed items such as the wavelength.

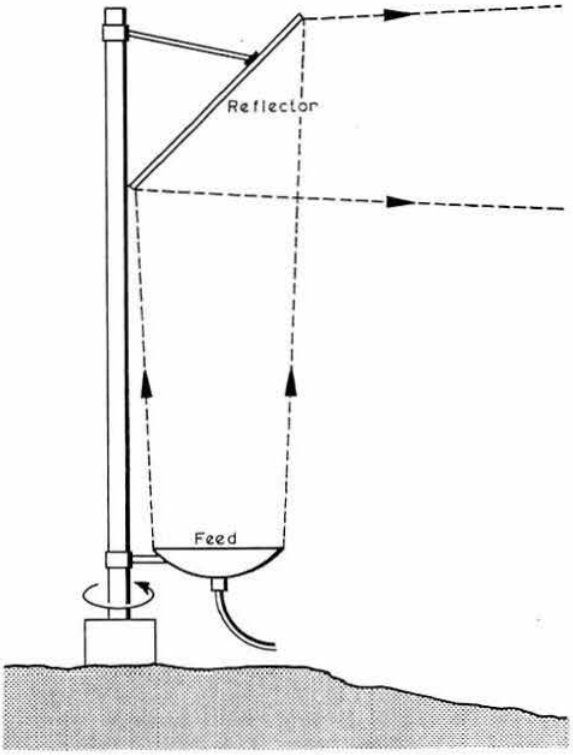

Fig 1. Configuration of flyswatter or periscope antenna

It is one of the problems of generalized data of this type that the interaction between the various factors may not be at all obvious: indeed, it is often easy to gain a quite misleading impression. There seems to be no other way of avoiding this and getting a "feel" for the topic other than to look at a fair number of examples, and this article represents the results of an exercise of this sort.

The way of using the data is as follows:

(*a*) Calculate the ratio a/R; ie the ratio of diameter of the dish feed and the minimum dimension of the reflector. If a feed other than a dish is used, then use the diameter of a dish of equivalent gain.

(*b*) Calculate the value of the function $\lambda d/4R^2$ remembering that λ, d and R must be in the same units.

(*c*) Determine from Fig 2 or Fig 3 the gain or loss corresponding to these values.

(*d*) Add this gain or loss to the gain of the feed.

Systems using plane reflectors

Fig 4 illustrates the effect of dish and reflector size on overall gain in systems in which the minimum dimension of the reflector is made equal to the diameter of the dish feed. The reflector is assumed to be mounted at an angle of 45° to the horizontal so that the maximum dimension is made 1·41 times the minimum.

The important feature of these results is that they show

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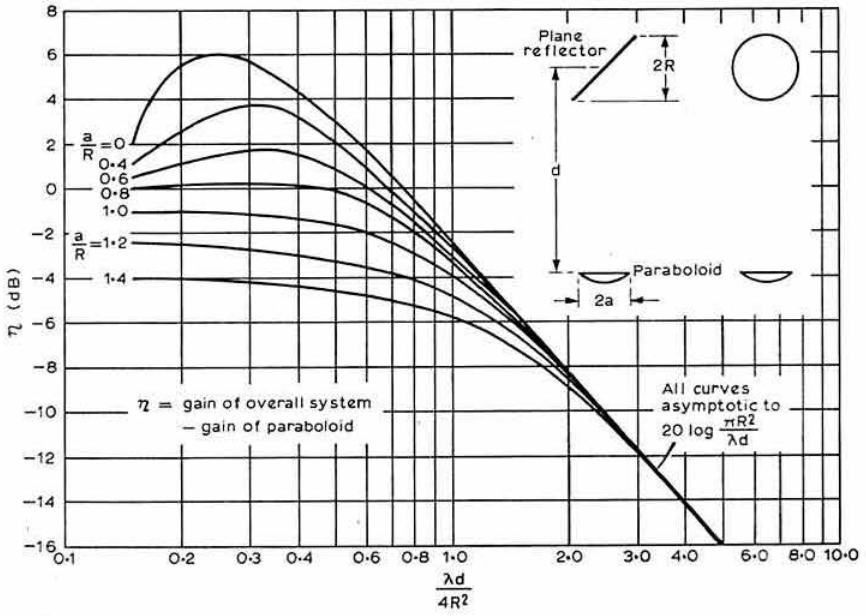

Fig 2. Relative gain with plane reflector [1]

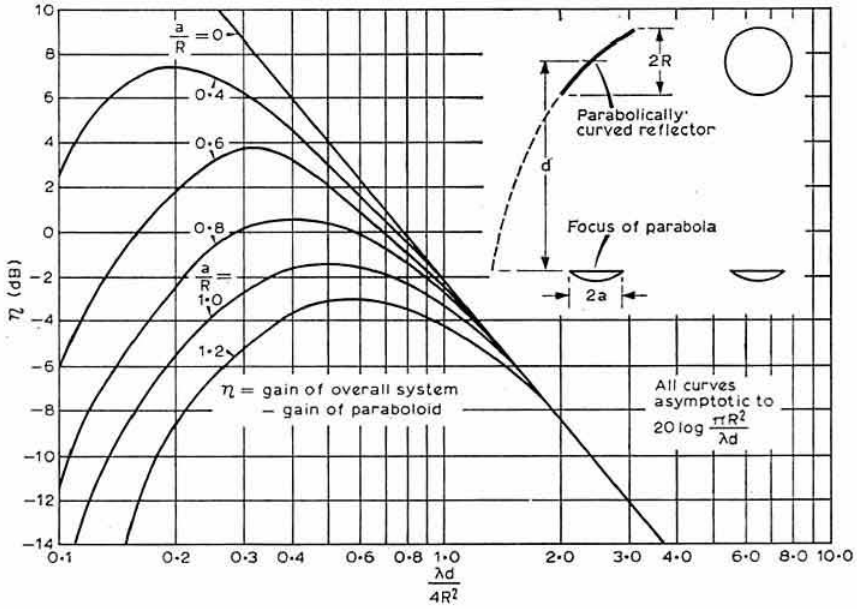

Fig 3. Relative gain with parabolically curved reflector [1]

that it is comparatively easy to achieve a reasonably high antenna gain in absolute terms despite the "transmission loss" being high in some cases. For example, a dish 1·5ft in diameter used with a reflector 1·5 × 2·1ft in size which is mounted 30ft up a mast will still have a gain of 25dB, despite a transmission loss of 5dB.

The effective "feeder" losses are interesting. With a dish 1ft in diameter, the loss is about 0·3dB/ft. Although rather high, it is still less than that characteristic of even good quality coaxial cable at this frequency. On the other hand, the loss with a dish 3ft in diameter is only about 0·05dB/ft, which is about the same as brass waveguide No 16. As would be expected, the losses when using 1·5 and 2ft dishes are at intermediate values, 0·2 and 0·1dB/ft respectively.

Fig 5 illustrates for two sizes of feed the rather complicated way in which the overall gain is related to the size of reflector used. The lowest curve refers to a small feed used with a small reflector, and its performance can hardly be described as sparkling. However, by using a larger reflector the performance of the system improves dramatically, with the

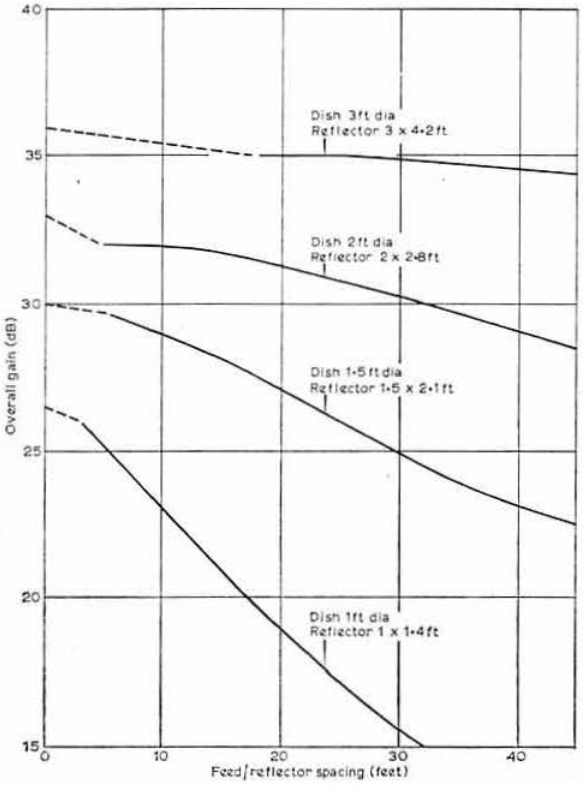

Fig 4. Overall antenna gain at 10GHz as a function of dish size, plane reflector same size as dish

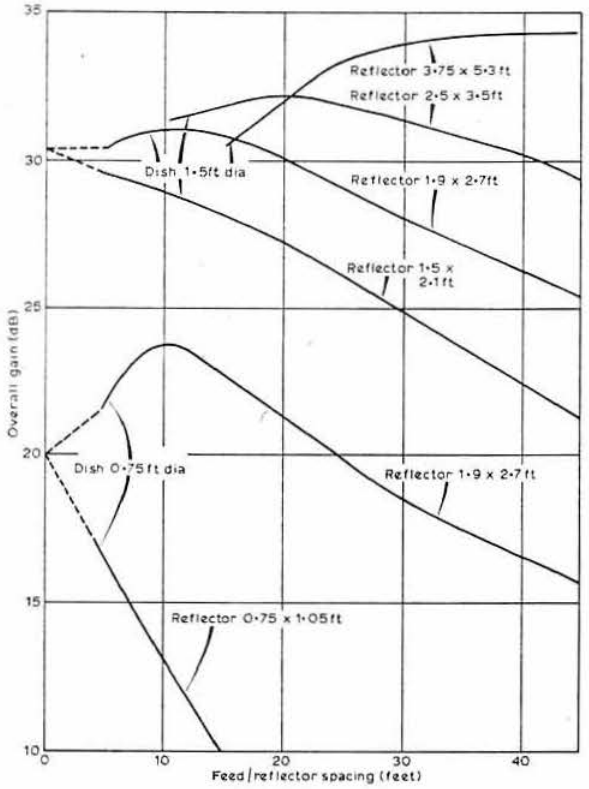

Fig 5. Overall gain at 10GHz for 0·75 and 1·5ft dishes as a function of plane reflector size

original 20dB gain still available at a feed/reflector spacing of 20ft. The upper four curves show the effect of reflector size with an "average" size of dish 1·5ft in diameter. Note that the peak gain is displaced to larger dish/reflector spacings which it may not be possible to use in a particular installation. At a spacing of 15ft, for example, the data suggest that the maximum overall gain is achieved with a reflector of *intermediate* size.

Systems using parabolically curved reflectors

The advantage of a curved reflector over a plane one is shown in Table 1, the values of gain being the maximum that can be obtained at each particular value of a/R. The advantage is significant only at low a/R ratios, that is when relatively large reflectors are used. Fig 6 shows the extent of the improvement for two sizes of dish feed, and again demonstrates that it may not always be practical to take advantage of these improvements.

Table 1—Comparisons of plane and curved reflectors

	Gain relative to dish feed		Advantage of
	Plane reflector	Curved reflector	curved reflector
a/R	dB	dB	dB
0·4	3·6	7·4	3·8
0·6	1·8	3·8	2·0
0·8	0·4	0·8	0·4
1·0	—1·0	—1·3	—0·3
1·2	—2·5	—3·0	—0·5
1·4	—4·0	—	—

This is simply because the enhancement of gain is observed over only a narrow range of values of the function $\lambda d/4R^2$, and that other considerations affecting the actual values of λ, d and R that have to be used may take it out of this narrow range. Even if the extra gain can be obtained, whether or not this justifies the effort of fabricating a curved reflector specially for the particular dish/reflector spacing to be used can only be decided in individual cases.

Variation of performance with frequency

Fig 7 shows how the overall gain varies with height at a number of frequencies of amateur interest for a system consisting of a feed dish 1·5ft in diameter with a plane reflector 3·75 × 5·3ft in size. The curves show that at lower frequencies not only is the gain of the dish feed reduced, but the transmission loss also tends to increase and thereby reduces the gain even further. The latter effect is a reflection of the displacement of the value of the function $\lambda d/4R^2$ to higher values as λ increases.

If a "standard" for antenna gain is taken as 20–25dB, a value obtained from 1 to 4 long Yagi antennas, then this particular flyswatter system will certainly be competitive at frequencies of 5·7GHz and above, and probably at 3·4GHz if feeder losses are taken into account. At 2·3GHz and below, this antenna clearly is not competitive. Nevertheless it is worth noting that, while it may not be justifiable to set up a reflector of *this* size specially for these lower frequencies, if

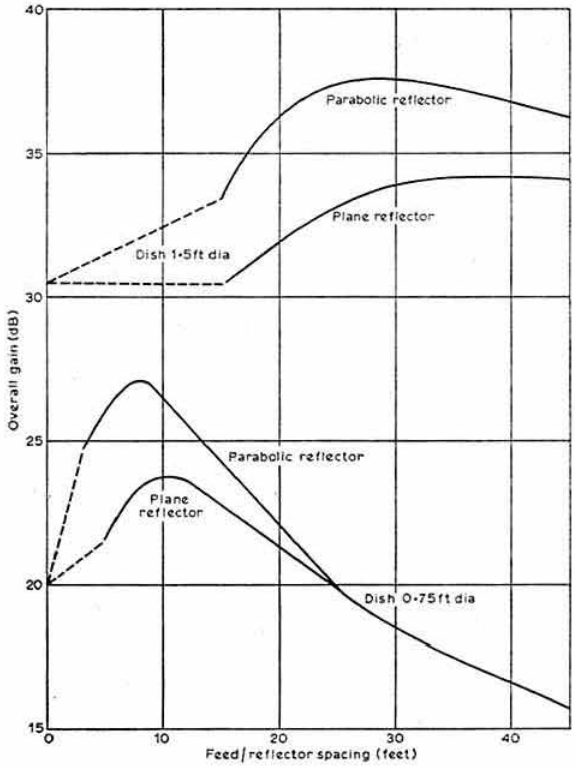

Fig 6. Comparison of plane and curved reflectors

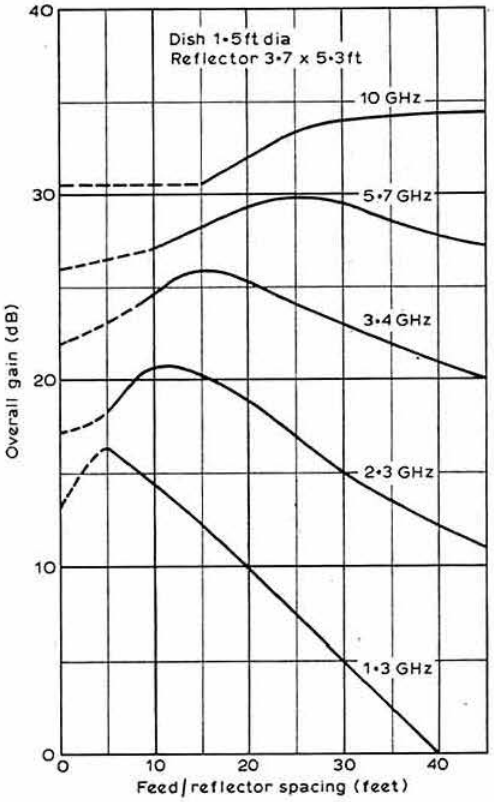

Fig 7. Gain of specified system as a function of frequency

one is already available then an antenna of moderate gain can be produced for the effort of just fitting a suitable feed.

Practical aspects of construction

Some of the factors affecting the construction of flyswatter antennas are as follows:

(*a*) With these and other high-gain antennas, the axis of rotation must be truly vertical otherwise the beam will point successively above and below the horizon as it is rotated. If this deviation is larger than a small fraction of the beamwidth of the antenna in the vertical direction, then the overall gain may be significantly reduced.

(*b*) It is not essential but it would appear simpler if the feed directs signals vertically upwards. A plane reflector in this case would be set at precisely 45° to the horizontal. Aligning the system would presumably only require the feed to be fitted with its centre immediately below that of the reflector, and the latter tilted to eliminate any squint while keeping the antenna peaked in azimuth. Curved reflectors will probably have to be set at the correct angle by trial and error.

(*c*) There is no reason why the feed should not be fitted some distance up the mast if this is more conventient for operating via, for example, a bedroom window.

(*d*) It is necessary that the reflector be flat, or curved parabolically, and not distort under wind pressure or other cause, within an overall error of $\pm$ $\lambda/10$. If a mesh reflector is used to reduce windage, then the spaces between the wires should not exceed $\lambda/10$ at the highest frequency of operation. For more details see [2].

(*e*) As noted earlier, there is no reason why horn or Yagi antennas should not be used as the feed.

(*f*) One of the advantages of the flyswatter system is that a vulnerable part of any antenna, the feed itself, is readily accessible. It would seem to be worth spending much effort to make it possible to remove, replace and interchange feeds reliably so full advantage can be taken of this accessibility.

Conclusions

The object of this work was to examine the flyswatter antenna system to see if it was likely to be of value in an amateur context. This would certainly appear to be the case, and it is suggested that the next steps should be to investigate the practical aspects of these systems in greater detail, and also their potential at lower frequencies. These will be dealt with in a later article which will also include, it is expected, the results of various trials.

References

[1] *Antenna Engineering Handbook*, ed H. Jasik, McGraw-Hill.

[2] *VHF/UHF Manual*, RSGB, third edition, pp8.52-8.53. □